Graphically defining articulable tacit knowledge

Peter Busch and Debbie Richards

Dept. of Computing
Macquarie University
Sydney, Australia 2109

{busch/richards}@ics.mq.edu.au

Abstract

Although codified knowledge and its capture is commonplace, tacit knowledge has up until recent years proved elusive in its inclusion within the organisation's knowledge base. Codified knowledge or articulate knowledge is knowledge that we are all quite familiar with and includes for all intents and purposes the entire range of printed and electronic media. We present here an approach aimed at graphically representing articulable tacit knowledge. It is anticipated that eventual successful modelling of such knowledge will ultimately be undertaken in several Sydney organisations with a view to improving information capture and transference. Two main approaches are demonstrated, the initial approach using formal concept analysis as a means of visualising tacit knowledge differences in questionnaire respondents, whilst the second approach is largely qualitative in nature and aims to better define both textually and then graphically what we may actually consider to comprise tacit knowledge.

Keywords: Tacit knowledge, Formal Concept Analysis, Qualitative Research, Network Maps, Lattices

1 Introduction

One is often tempted in commencing any research to provide an explanation for why such research should take place to begin with. Reasons for attempting to study tacit knowledge are numerous, however Tuomi (1999/2000) has summed up one aspect quite succinctly:

> If the design principles and methodology cannot address the tacit component, it cannot tell us where and how much we should invest in the explication of knowledge. In general, it can be argued that there has been too little emphasis on the sense - making aspects of information systems. This is becoming an increasingly important issue as information systems are increasingly used for collective meaning processing (:111).

But what is tacit knowledge? Tacit knowledge is that which is used by all people but not necessarily able to be easily articulated (Polanyi 1967). Examples include knowing how tight to make a bandage, or whether a senior surgeon feels an intern may be ready to learn the intricacies of surgery.

Our research is attempting to solve several issues in relation to tacit knowledge. We wish firstly to explore in greater detail the relationship between articulate and tacit knowledge, with an emphasis on the practical application of the latter. We would also like to explore the presence of tacit knowledge in expert systems. Another goal is to examine differences between the private and public sectors in terms of their tacit knowledge usage. In order to help us accomplish these goals we must first determine how tacit knowledge can best be measured at the individual level, and also how tacit knowledge may be more effectively represented, other than merely as a sequence of definitions.

We begin by providing a technique we have refined for graphically measuring tacit knowledge at the individual level, and then we provide a qualitative textually based alternative, which in turn handles graphical visualisation of tacit knowledge in a very different way

2 A brief definition to tacit knowledge

> We have no idea how we do a lot of the things that we know how to do. Among those are the very fast feats of perception, recognition, attention, information retrieval, and motor control. We know how to see and smell, how to recognise a friend's face, how to concentrate on a mark on the wall … These are definitely tacit competencies. If there are rules involved, we have no idea what they might be (Dahlbom and Mathiassen 1999 :33).

Within an organisational context we as humans make use of knowledge that is not necessarily codified or even articulated. This knowledge is said to be tacit, yet comprises a viable source of information which is nevertheless largely able to be articulated. It is important to distinguish between tacit knowledge that is embodied in skills and can therefore be copied, and tacit knowledge that cannot be demonstrated and so is very difficult to transfer (eg. the recognition of a musical note) (Senker 1995). We need to realise that a proportion of tacit knowledge can never actually be articulated (Leonard and Sensiper 1998), for "much of it is not introspectable or verbally articulable (relevant examples of the latter would include our tacit

---

knowledge of grammatical or logical rules, or even of most social conventions)" (Pylyshyn 1981 :603). Nevertheless many social conventions such as etiquette sets or what constitutes proof, become codified over time (Busch and Dampney 2000) as a practical matter because the parties involved accept, agree or submit to the conventions, rules, laws (or the means of arriving at them) as the case may be. In actual fact there is likely to be a knowledge hierarchy where the greater proportion of our present day knowledge has originally arisen from embedded tacit knowledge that has slowly become codified or articulated over time.

3 Formal Concept Analysis as a means of measuring articulable Tacit Knowledge

To date a great deal of literature exists on the phenomenon of tacit knowledge in the workplace (Johannessen, *et.al.* 1997; Lei 1997; Nonaka *et.al.* 1996; Raghuram 1996; Nonaka 1991), however little in the way of methodology is available for the measurement for such knowledge other than that proposed by Sternberg (*et.al.* 1995) and his Yale University research group. The Yale approach typically makes use of a Likert scale (figure 1), for a sequence of scenarios for which respondents are asked to pick a rank and potentially also to write 'plans of action' for how they would handle each of the allocated answers below the scale. For a typical Tacit Knowledge test there would be in the order of 12 scenarios each having between 5 – 20 response items per scenario, for which a score on the Likert scale must be chosen. If one then considers that there would be an additional bibliographical component in the same questionnaire, it would not be unusual to thus have a respondent answer in the order of 130 questions. We had at first considered placing some 24 scenarios with between 5 – 6 answer items per scenario in our questionnaire, but felt that the Sternberg approach made more sense, as fewer scenarios (i.e. 12) would require respondents to shift their frame of mind to a new scenario less often, whilst being able to respond to the intricacies of a scenario in greater detail (i.e. 5 – 20 response items instead of 5 – 6). For the pilot study, the results of which make up the initial component of this paper, we have used only one scenario with 5 answer items (for further discussion of the scenario, please refer to Richards and Busch 2000).

We have conducted a small pilot with 14 participants. The results of our questionnaire (table 1) and the formal context shown in figure 2 only includes the data to the fifth answer option. This is a small subsection of the data we gathered for the pilot study. In the complete study there will be 700 primitive concepts (20 scenarios, each with 5 answer options using a 7-point Likert scale) plus approximately 40 IT jobs and 12 biographical factors. Handling such a large number of concepts, from which we will generate many high level concepts, is computationally expensive and impractical to display. We use a tool and technique we have developed and introduced at *SoftVis99* (Richards 1999), known as MCRDR/FCA, to restrict the context so that the number of concepts may comprehensibly be displayed on a typical computer screen (Richards and Compton 1997). This tool is based upon work on Formal Concept Analysis conceived by Wille (Ganter and Wille 1999). The Concept Lattice in figure 2 has been generated by selecting participants who in this instance saw answer option 5 as a good or better alternative. Note that good subsumes very good and extremely good. Looking at the Formal Context in figure 2 we can see that this will include participants P1, P4, P11, P12, P13 and P14.

Rate the following points on a 1 - 7 point scale

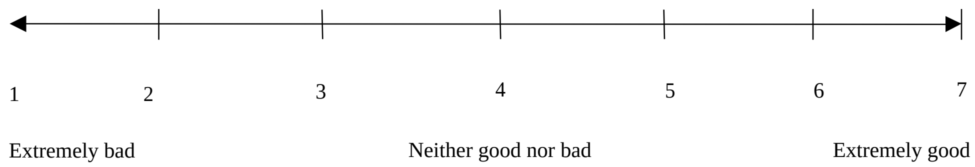

Figure 1: A sample of a Likert scale which is used to answer options

Scenario subject	No.	Response	Choice	Participants													
				P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
Privacy and management reporting	5	Blow whistle	Extremely good											X			
			Very good													X	
			Good	X			X								X		X
			Neither					X				X					
			Bad			X				X							
			Very Bad		X						X		X				
			Extremely bad						X								

Table 1: Subsection of Formal Context for answer option 5 and corresponding participant choices

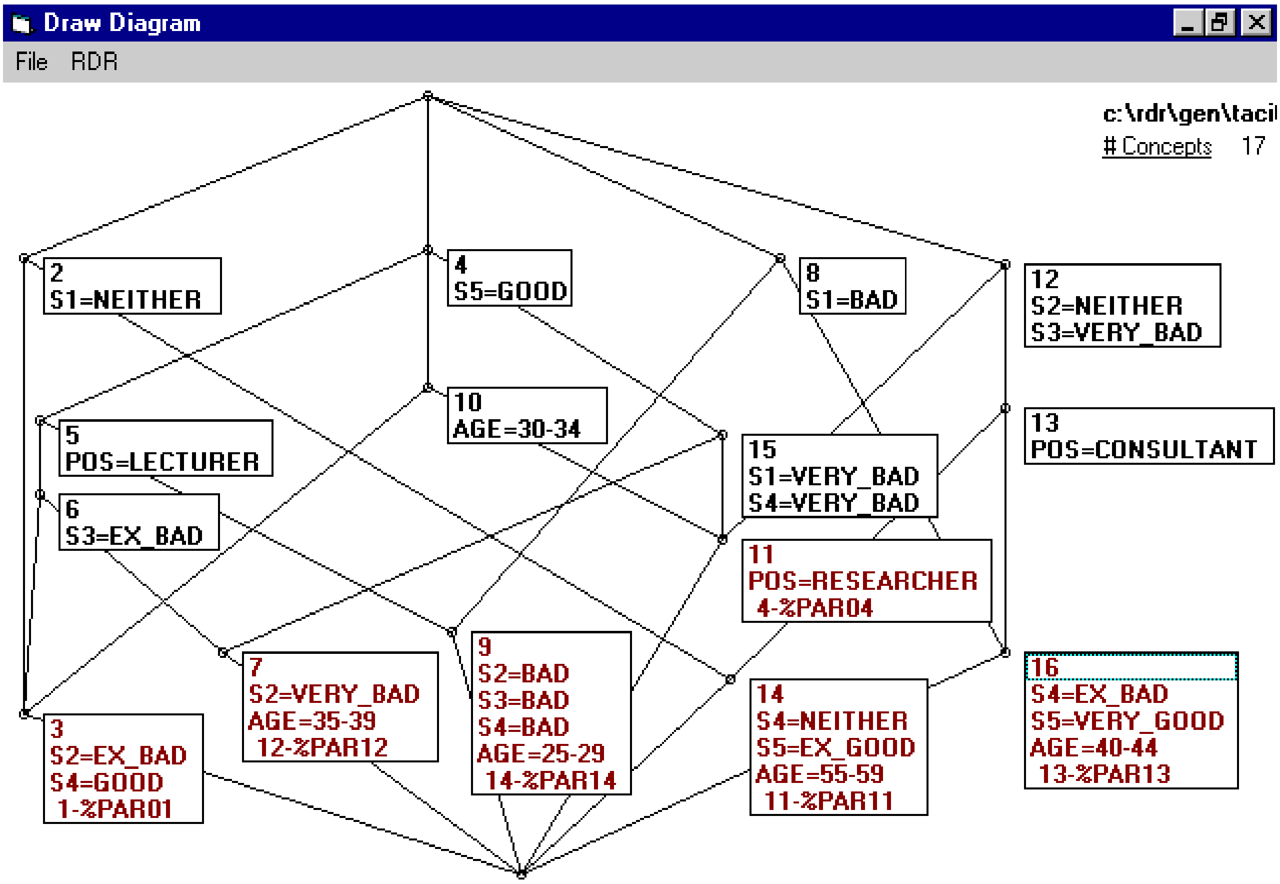

Figure 2: Concept lattice showing the features and responses of participants who found response 5 to be a good, very good or extremely good option to scenario 1

An examination of figure 2 reveals a great deal of information. The data has been encoded to allow it to be used in our tool and requires some explanation. The 5 answer options have been identified as S1, S2, S3, S4 and S5. Participants have been identified according to the sequential number assigned to each primitive concept in the Formal Context, the % symbol and the coding PARNN where NN is the participant number (this awkward labelling is based on our original use of the MCRDR/FCA tool to model rules from a particular type of KBS). Each concept in the lattice is shown as a small circle. The label describing the concept is attached to the right of the circle. Labelling has been reduced for clarity. In FCA a concept is a set of attributes and the set of objects that share them. The set of attributes that belong to a concept are reached by ascending paths and the objects that belong to a concept are reached by descending paths. Thus, we can see in figure 2 that concept number 10 includes the attributes (or in our usage the participant's choices and features) {S5=Good, Age=30-34} and the objects {Participant 1, Participant 4}. While these two participants made the same choice for answer option 5, they differ in the positions they hold and their choices to the other answer options.

We can also see that participant 1 shares certain attributes with each of the other participants except for participant 13. Participant 1 and 12 share their positions and choices to answer options 3 and 5. Participant 1 and 14 share their positions and choice to answer option 5. Participant 1 and 11 share their choice to answer option 1. It is interesting that participants 11 and 13 are both consultants who made the same choice to answer options 2 and 3 and their choices to answer options 1 and 5 are only a distance of 1 apart on the Likert scale. Their ages and choice to answer option 4 are a distance of 3 and 2 apart, respectively, on the Likert scale. The difference in ages may not be significant since both would be considered mature age and it does not indicate the number of years they have been in the consulting position. There are many further comparisons that can be made and we invite the reader to look further at some of the relationships revealed in the concept lattice in figure 2.

Bear in mind that we are showing differences in tacit knowledge utilisation between individuals in using this technique. From comparing these results to those results from a group of ‘experts’ in any subject domain we may then illustrate which individuals have more tacit knowledge than others.

4 Models of tacit knowledge

Let us now turn our attention to an entirely different means of attempting to define graphically what articulable Tacit Knowledge could be considered to be, this time from a fundamentally qualitative point of view. Given that the definitions of tacit knowledge are overwhelmingly textual in nature, we felt it best to use these definitions so that models could be developed that would graphically represent what Tacit Knowledge could be said to mean. A picture may be said to be worth a thousand words, and it is essentially for this reason that ‘network maps’ are able to reresent by way of grounded theory concepts that which text in itself is unable to do. To that end we have conducted qualitative research using ATLAS.ti™, which permits the ‘coding’ of text from primary text documents.

> ATLAS/ti is a powerful workbench for the qualitative analysis of large bodies of textual, graphical and audio data. It offers a variety of tools for accomplishing the tasks associated with any systematic approach to “soft” data, e.g. material which cannot be analysed by formal, statistical approaches in meaningful ways. In the course of such a *qualitative analysis* ATLAS/ti helps you to uncover the complex phenomena hidden in your data in an exploratory way (Muhr 1997 :1).

Having established a ‘hermeneutic unit’ or related set of primary text documents, which represents the information to be coded up, we may then proceed in coding up the text, whereby the codes or nodes correspond to anchor points. We use the term code and node concomitantly here, for they stand for essentially the same thing. Having established codes we are then able to ‘map’ these into network diagrams, which require the concurrent establishment of relationships or links between the codes (or nodes) for the network maps to be successful. The underlying basis of these network maps is not dissimilar to graph theory. A subjective component is implicit within the creation of nodes as well as the creation of relationships between the nodes, as is of course the case in any information modelling activity.

5 Atlas.ti software in detail

An examination of figure 3 reveals a screen dump of the *ATLAS.ti*™ software. Beginning with the background screen we may note that there are 4 small windows apparent at the top of the screen. The far left window represents the primary text documents that are coded up. The next window captures all quotations within the coded up document. The third window contain the codes themselves, whilst the fourth window relates to memos one may wish to create whilst allocating a code to some text.

The major background screen provides an example of a document that has been coded, with the codes themselves relevant to this piece of text represented in the right hand window. Note colour is added by ATLAS.ti™ to the codes to indicate depth of coding. Furthermore clicking on any one code allows one to follow back in other primary text documents where a particular code may have been used previously.

Other visible features in figure 3 include buttons along the left hand side of the screen that merely serve to provide a graphical shortcut of the features that are ordinarily encountered in the menu options along the top of the screen.

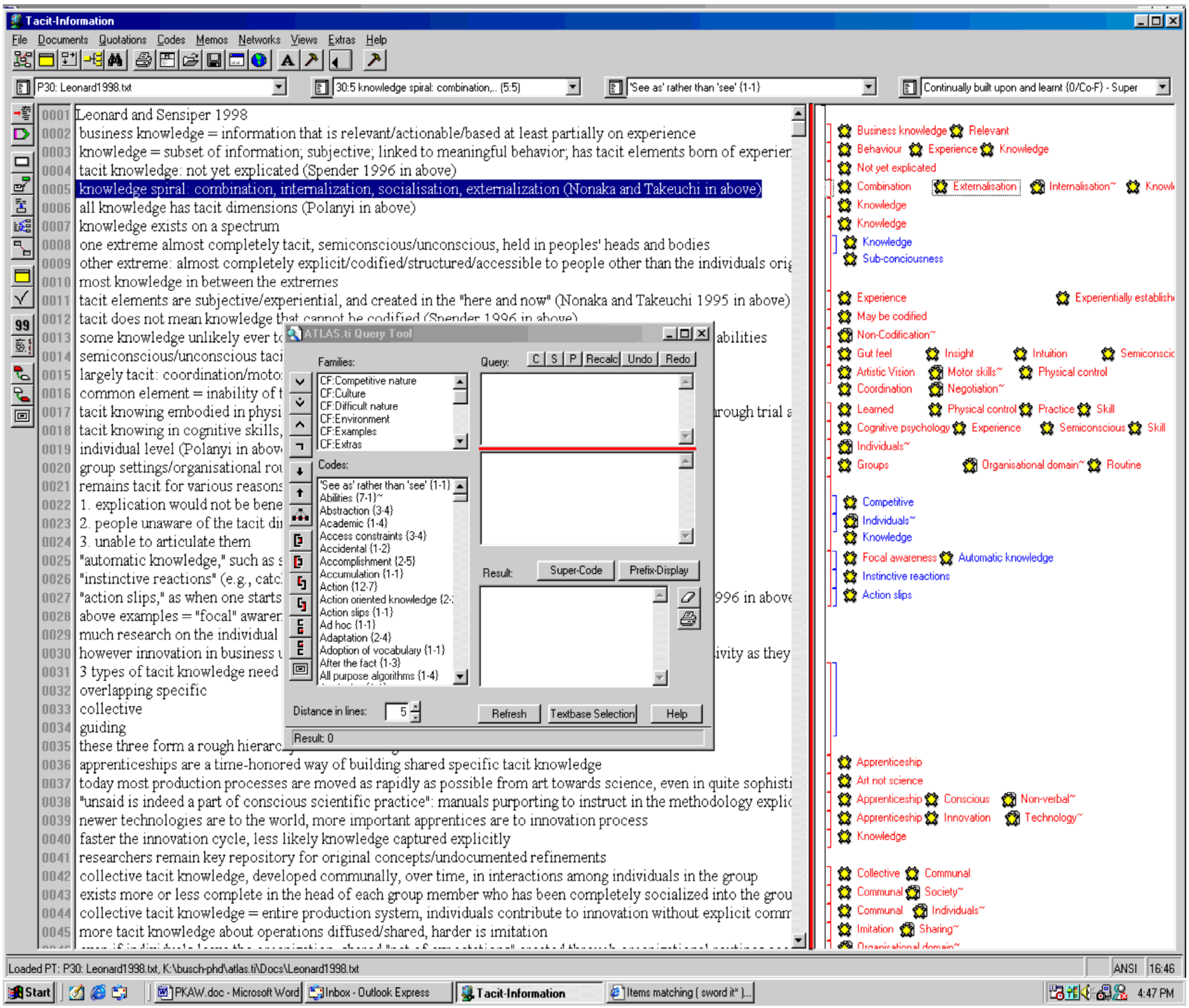

Figure 3: illustrating a screen dump of the *ATLAS.ti*™ hermeneutic unit for articulable Tacit Knowledge

If we now turn our attention to figure 4, we are able to visualise the relation editor, which in this case has been placed in front of a network map. The relation editor permits the qualitative researcher to define the edges of a graph or in this case the types of relationships that exist between codes. Whilst there is of course only one relation that may be expressed between any two nodes, and this relation is fixed throughout the hermeneutic unit, any number of relations may be created representing all sorts of relationships between all the other nodes. Ideally however limitations in the diversity of relationships are necessary as the application of a similar relation to another set of codes enables easier comparison both visually (by way of colour) and in terms of hierarchy that may exist between one relation and another. For example whilst some relations are subsumed by others, some are in fact at the same level of hierarchy, but simply represent different relationships between nodes.

Typical relations are those of: is – associated – with; is – part – of; is – cause – of; is – composed – of; contradicts; is – an – example – of; is –a; leads – to; and is – property – of. Notice the importance of colour. Although network maps may be represented in black and white, a consequent large amount of data loss takes place nevertheless.

In table 2 we have summarised the key codes evidenced within the literature of tacit knowledge. In our attempt to define what tacit knowledge may represent, we have chosen to show in this instance only those codes with a incidence of greater than 8 within our primary text documents. In other words, where a line of text has been marked up, only those codes that occur most commonly within a content analysis paradigm have been included within this table. For example one can see from table 2 that ‘knowledge’ is a key term with a groundedness (or occurrence) of 80 instances within the literature, ‘individuals’ in turn can be seen to have a groundedness of 50, whilst ‘understanding’ has a groundedness factor of 9.

The reader should note however that the codes represented in table 2 are not exhaustive as they constitute only those codes with the highest levels of groundedness, and we may see that there are some 1,310 instances of all codes combined being utilised in our qualitative analysis of the literature. The total number of codes in our hermeneutic unit for tacit knowledge are 450 in total. Most of the codes however have a groundedness of 1 (266 instances).

As further evidence of the subjective nature of our qualitative approach to using ATLAS.ti™, one should note that the groundedness of codes utilised and the name actually allocated for each code is up to the individual. Therefore another individual may allocate slightly different code names and use a certain code more often than another. Qualitative research does not necessarily aim to be replicable however.

The minimal level of data that is able to be displayed in a table is the reason we are better off using network maps which permit relationships to also be meaningfully modelled.

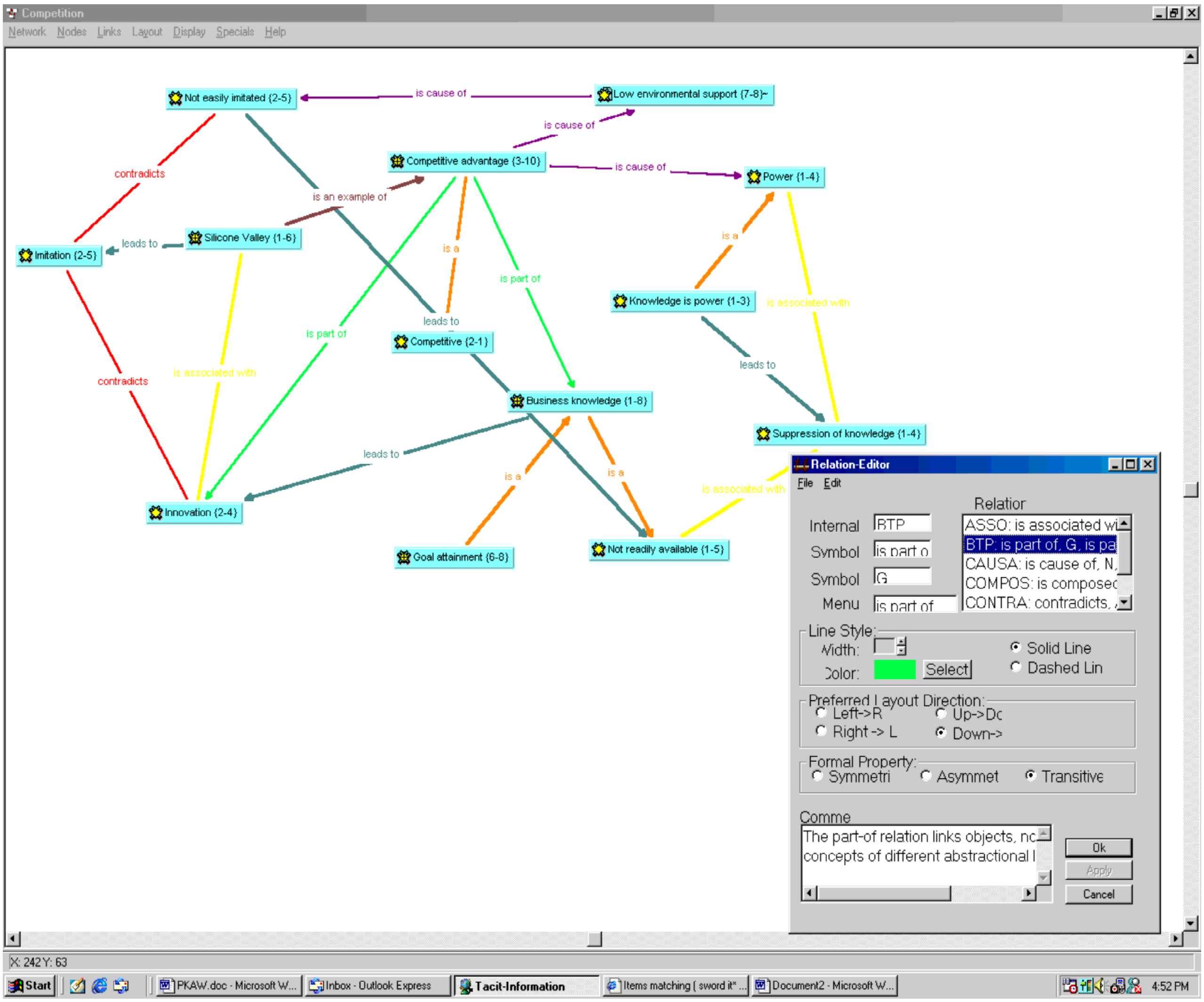

Figure 4 illustrating the relationship editor in conjunction with a network map

Knowledge	80
Individuals	50
Organisational domain	46
Skill	35
Non-Codification	28
Non-verbal	27
Experience	26
Context specific	24
Intuition	20

Learned	16
Know how	15
Not formal	13
Action	12
Expertise	11
Culture	10
Contingency based	9
Environment	9
Externalisation	9

Knowing	9
Not easily communicated	9
Practical	9
Sub-consciousness	9
Understanding	9
Totals	**1310**

Table 2 illustrating occurrence of codes >8 within the network maps (note the incidence of 'knowledge', 'skill' and 'individuals')

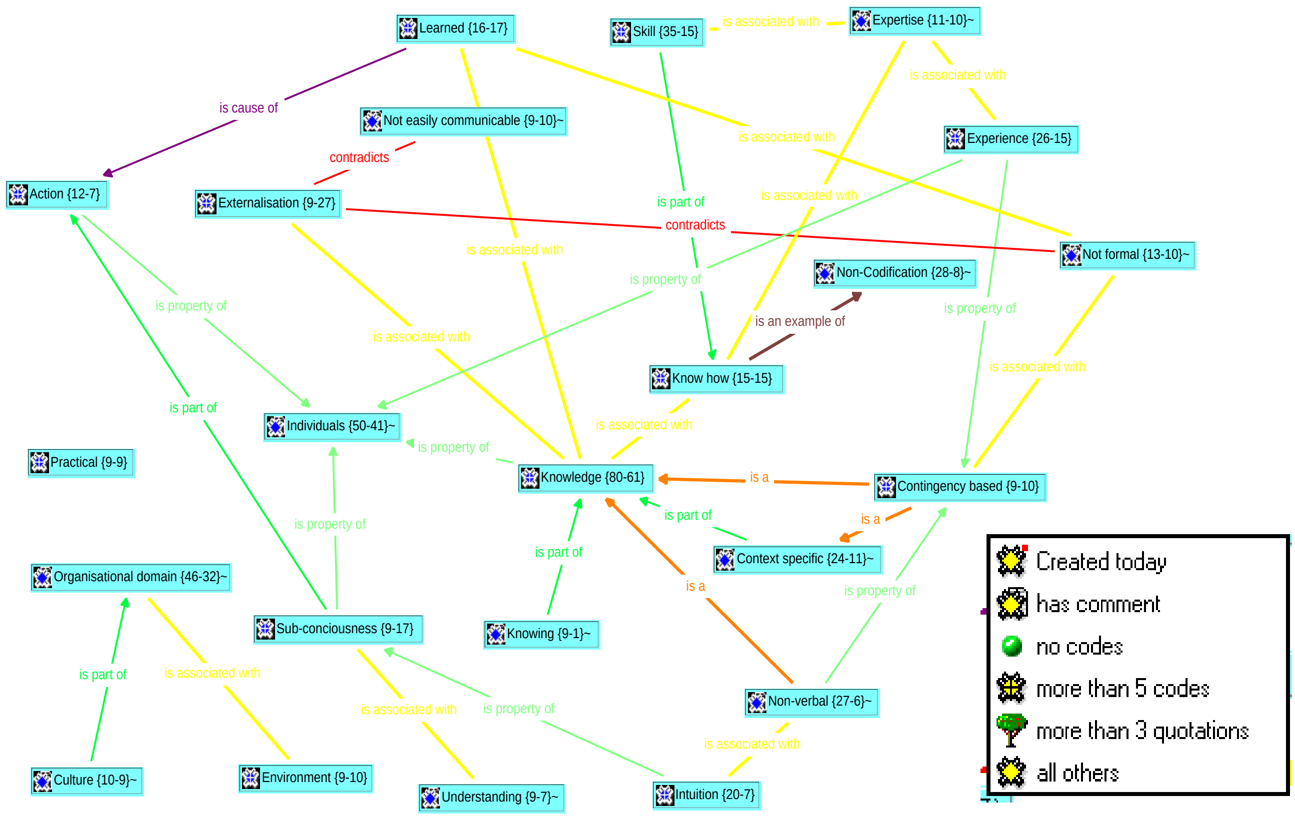

Figure 5: Representing a network map of Tacit Knowledge where code occurrence is > 8

If we examine a comparative network map with instances of codes greater than 8 (figure 5), we see clearly a great deal more information. Not only is the user more easily able to identify the relationships between each code by way of the text represented on each relationship line, the use of colours which is so necessary in such a network map immediately permits the viewer to identify the levels of complexity of the relationships themselves. For example, we have used a red colour in this instance to identify contradiction between one node and another. In other words where we as researchers see a code conflicting with another we are able to visually identify this trend. Colour coding thus permits instances of 'aggressiveness' or 'passiveness', or 'similarity' and 'dissimilarity' to emerge from the literature.

Note the prominence of codes representing 'know – how', 'organisational domain', 'non codification' and 'context specific'. These may be said to represent themes, which are commonplace in the literature. Note also that not all codes are interconnected in figure 5, due to the fact that we have used a Top 8+ code family within the software that permits only those relevant codes to be included in the map. What this means is that although codes may be linked in other network maps elsewhere, some of the codes are not necessarily linked here, because the codes with which they are connected are simply not shown in *this* (figure 5) network map. Once a node/code is connected it remains connected with however many other codes there are. Other items of interest in the network model are the notations represented in the key (figure 5). Although we may see from our key that there were no codes 'created today', all of the other code types are shown in the network map. What are particularly important however are the numerical values that appear on each code. The first represents code groundedness, in other words the number of times the code has appeared in the primary text literature, "the larger this number, the more evidence has already been found for this code in the data". The second numerical value represents code – network density, or in other words, the number of times the code has been linked to other codes, "codes with large numbers can be interpreted as having a high degree of theoretical density" (Muhr 1997 :40). Using such numerical values, although not fully in the interpretevistic tradition, does at least permit us to gauge the importance of the codes in question.

In our second network view (figure 6) we are able to see how codes relate specifically to *Competition* as a theme within Tacit Knowledge. Although 'competitive advantage' as a code only has a groundedness of 3 (meaning 3 instances of the code being used), and 'competitive' a groundedness of 2, an examination of figure 6 reveals that in actual fact a number of other codes relate to the competitive nature of tacit knowledge. The reason for the competitive nature is summed up by Sternberg (*et.al*. 1995):

Knowledge acquired in the face of low environmental support [groundedness of 7, network density of 8 in figure 6], often confers a comparative advantage and thus tends to be practically useful in a competitive environment. When knowledge must be acquired in the face of low environmental support, the probability that some individuals will fail to acquire it increases. When some individuals fail to acquire knowledge, others who succeed in acquiring the knowledge may gain a competitive advantage over those who fail to acquire it. Note that the magnitude of this advantage would be lower if the knowledge in question was highly supported by the environment (i.e. explicitly and effectively taught), because more people would be expected to acquire and use it. Because many of the goals that individuals personally value are pursued in competition with other people, one may speculate that knowledge acquired under conditions of low environmental support is often particularly useful. This knowledge is more likely to differentiate individuals than is highly supported knowledge (:917 – 918).

Notice how in figure 6 ‘imitation’ also appears as a code that arises from the literature. We can of course visualise the relationship this code has with others such as ‘not easily imitated’ and ‘innovation’, the latter two of which are also codes that represent tacit knowledge as a construct. ‘Business literature’ is also an important component of our network map insofar as whilst this code only has a groundedness of 1, it nevertheless has a network density of 8, meaning that its degree of code interconnection is quite high. We are only able to see its interconnection with 4 other codes in figure 6, nevertheless there are obviously other codes it is connected with in other maps.

Our final figure (figure 7) focuses on *Learning* as a component of tacit knowledge, for tacit knowledge is typically passed on in a 'master - apprentice' role, rather than by way of more formalised means of instruction. Nonaka, Takeuchi and Umemoto (1996) illustrate the tacit knowledge explication cycle by way of a 4 stage process from externalisation (tacit to explicit), codification (explicit to explicit), internalisation (explicit to tacit) and socialisation (tacit to tacit). Although each of these stages are considered to be as influential as the other, it is the externalisation stage that is of most interest to us because we would like to explicate whatever tacit knowledge there may be to incorporate such knowledge within our systems.

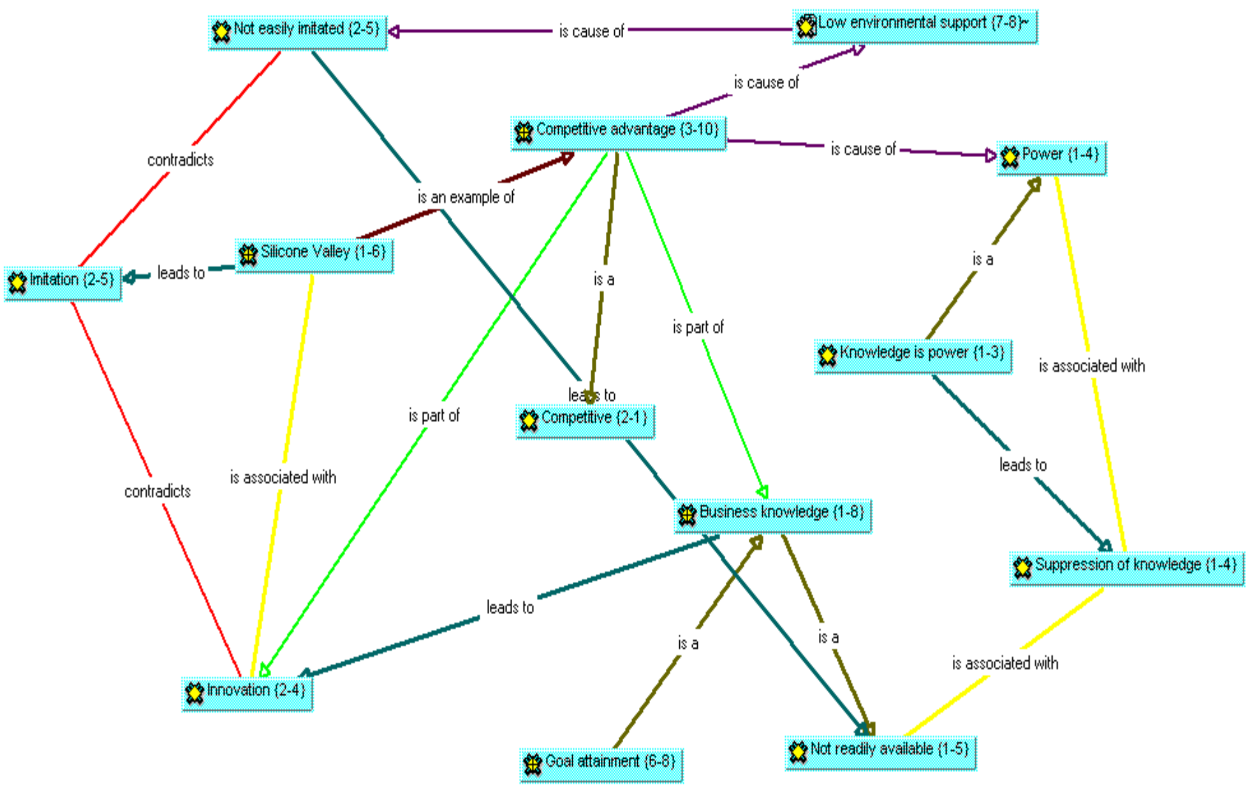

Figure 6: Network view of *Competition* (as a theme) and Tacit Knowledge

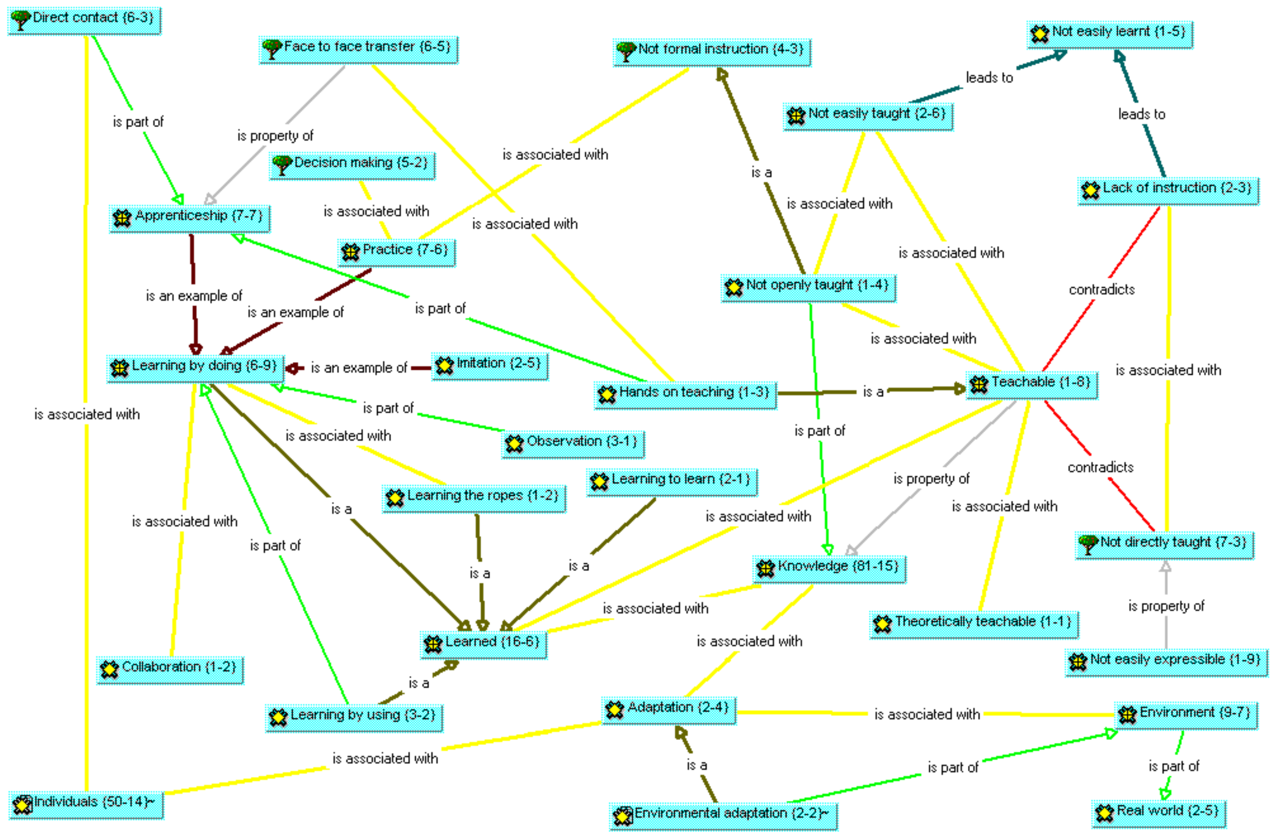

Figure 7: Network view of Learning (as a theme) and Tacit Knowledge

From a learning perspective, we require tacit knowledge to be spelled out, either verbally if possible or by a sequence of actions. The former is directly an example of externalisation, the latter is an example of socialisation and may take the form of using metaphors or analogies to get our message across.

> When we attempt to conceptualise our image, we express its essence mostly in language – writing is an act of converting tacit knowledge into articulable knowledge (Emig 1983 in Nonaka, Takeuchi and Umemoto 1996). Yet, expressions are often inadequate, inconsistent, and insufficient. Such discrepancies and gaps between images and expressions, however, help promote reflection and interaction between individuals. ….When we cannot find an adequate expression for our image through analytical methods of deduction or induction, we have to use a non - analytical method. Externalisation is, therefore, often driven by metaphor and/or analogy. Using an attractive metaphor and/or analogy is highly effective in fostering direct commitment to the creative process (Nonaka, Takeuchi and Umemoto 1996 :837).

Looking at figure 7 we can see that 'learning by doing' (groundedness of 6, network density of 9), is a central component of tacit knowledge acquisition. Note also the prominence of 'learned' as a whole (groundedness of 16, density of 6). The codes present in figure 7 such as 'not directly taught', and 'lack of instruction' also further highlight the 'socialisation' aspects of tacit knowledge discussed previously, in other words in order for tacit knowledge to be passed on, it has to be done so in a social rather than book – oriented explicit knowledge situation. Furthermore as figure 7 reveals although tacit knowledge instruction does reveal the fact that it is not generally taught, we may see that the presence of codes such as 'theoretically teachable' and 'learning the ropes' nevertheless indicate that it *is* able to be passed on nevertheless.

6 Conclusion

We have discussed what we consider to be major themes emerging from our study of tacit knowledge. Such knowledge has the following characteristics. It is the source of knowledge in that it is the basis for knowledge gathering, generation and diffusion. It eventually becomes codified in practice as individuals, organisations and finally all of us learn by its successful application. It becomes codified in theory by its reduction to simple underlying principles. One may feel tempted to ask whether tacit knowledge is not simply another test for intelligence, yet evidence (Wagner and Sternberg 1985; Wagner 1991 in Brockmann and Anthony 1998) would seem to suggest that that it is not, rather it is more a general level of 'ability' which tends to define the successful from the less successful.

We have used two fundamentally different approaches to providing a visual perspective as to what tacit knowledge constitutes. Our initial approach is of a more positivistic nature, making use of survey questionnaire returns and then using formal concept analysis as a means of assessing individuals in terms of their tacit knowledge similarities. Such research is based upon the work of psychologists such as Sternberg's group at Yale that seeks to test tacit knowledge differences in individuals by means of expert – novice comparisons. Our approach differs insofar as we attempt to visualise the differences by way of formal concept analysis lattices.

Our second approach to tacit knowledge modelling was to attempt to define how one may actually model definitions of what such knowledge may constitute. We began by using a qualitative approach with ATLAS.ti™ software that permits the coding or marking up of literature dealing with tacit knowledge. The codes themselves thus may be used to form network maps that permits us to pictorially determine what the themes are within a hermeneutic unit. We chose to concentrate on two particular network maps, namely those of competition and learning as themes to arise from the literature. The maps were successful in that they provided visual support for what was discussed textually.

We do not conclude by stating that our research has been exhaustive, but we have taken significant steps towards providing a visual alternative to what is ordinarily treated purely at the textual level. Our approach has attempted to model not only how tacit knowledge may be illustrated comparatively from one individual to the next, but also how we may graphically define what the ingredients of tacit knowledge constitute.

7 References

BROCKMANN, E. and ANTHONY, W., (1998): The influence of tacit knowledge and collective mind on strategic planning *Journal of Managerial Issues* Pittsburg; Summer (electronic)

BUSCH, P., and DAMPNEY, C., (2000): Tacit Knowledge Acquisition and Processing within the Computing Domain: An Exploratory Study *2000 Information Resources Management Association International Conference* May Anchorage, AK, U.S.A :1014 –1015

CHANDRASEKARAN, B., and JOHNSON, T. (1993): Generic Tasks and Task Structures in *Second Generation Expert Systems* Springer, David, J.M., Krivine, J.-P. Simmons, R. (eds.) Berlin, 232-272.

DAHLBOM, B., and LARS MATHIASSEN, L., (1999): *Computers in context: The philosophy and practice of systems design* Blackwell Oxford U.K.

GANTER, R., and WILLE, R., (1999): *Formal concept analysis: Mathematical foundations* Springer - Verlag Berlin Germany

JOHANNESSEN, J., OLSEN, B., and OLAISEN, J., (1997): Organising for Innovation *Long Range Planning* **30**(1) February :96 – 109

LEI, D., (1997): Competence Building, Technology Fusion and Competitive Advantage: the Key Roles of Organisational Learning and Strategic Alliances *International Journal of Technology Management* **14**(2/3/4) :208 – 237

LEONARD, D., and SENSIPER, S., (1998): The role of tacit knowledge in group innovation *California Management Review* Berkeley; Spring (electronic)

MUHR, T., (1997): *ATLAS.ti: The knowledge workbench: Short User's Manual* Scientific Software Development Berlin Germany

NONAKA, I., (1991): The Knowledge Creating Company *Harvard Business Review* **69**(6) November – December :96 – 104

NONAKA, I., TAKEUCHI, H., and UMEMOTO, K., (1996): A Theory of Organisational Knowledge Creation *International Journal of Technology Management* **11**(7/8) :833 – 845

POLANYI, M., (1967): *The tacit dimension* Routledge & Kegan Paul London U.K.

PYLYSHYN, Z., (1981): The imagery debate: Analogue media versus tacit knowledge *Readings in Cognitive Science: A perspective from Psychology and Artificial Intelligence* (eds. Collins, A., Smith, E.,) Chapter 6.5 Morgan Kaufman San Mateo California U.S.A. :600 – 614

RAGHURAM, S., (1996): Knowledge creation in the telework context *International Journal of Technology Management* **11**(7/8) :859 – 870

RICHARDS, D, and COMPTON, P, (1997): Combining Formal Concept Analysis and Ripple Down Rules to Support the Reuse of Knowledge *Proceedings Software Engineering Knowledge Engineering SEKE'97*, Madrid 18-20 June 1997, 177-184.

RICHARDS, D., and BUSCH, P., (2000): Measuring, formalising and modelling Tacit Knowledge *International Congress on Intelligent Systems and Applications (ISA2000)* December 12 – 15 2000 (accepted)

RICHARDS, D., (1999): Visualising knowledge based systems *SoftVis'99: Proceedings of the third software visualisation workshop* 3rd. – 4th. December 1999 UTS Sydney :1 - 8

SENKER, J., (1995): Networks and tacit knowledge in innovation *Economies et societes* **29**(9) September :99 – 118

STERNBERG, R., WAGNER, R., and WILLIAMS, W., HORVATH, J., (1995): Testing common sense *American psychologist* 50(11) November :912 – 927

TUOMI, I., (1999/2000): Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory *Journal of Management Information Systems* **16**(3) Winter :103 – 177 (electronic)

WAGNER, R., and STERNBERG, R., (1985): Practical intelligence in real – world pursuits: The role of tacit knowledge Journal of personality and social psychology **49**(2) August :436 – 458